





## Method of producing a dental restoration using CAD/CAM

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### Abstract of EP0824897

A method of making a dental porcelain restoration comprises providing a soft-sintered dental porcelain pellet; milling the soft-sintered pellet under the control of a CAD/CAM system to provide a tooth structure; investing the tooth structure with an investment refractory material to provide an invested tooth structure; fusing the invested tooth structure; and removing the investment refractory material from the fused tooth structure to provide the dental restoration.

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**(54) Method of producing a dental restoration using CAD/CAM**

Herstellungsverfahren für Zahnersatz mittels CAD/CAM

Méthode de restauration dentaire au moyen de CAD/CAM

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## Description

### FIELD OF THE INVENTION

[0001] This invention relates to a method of producing a dental restoration and, more particularly, to a method which employs CAD/CAM.

### BACKGROUND OF THE INVENTION

[0002] Dental porcelains are typically comprised of a fine powder of "glass-like" particles, e.g., Optec™ porcelain powder sold by Jeneric/Pentron Incorporated (Wallingford, Connecticut). To fabricate a dental restoration, water or some suitable liquid is added to the powder. A wet, sandy mix is created which can be formed into desired shapes and then fused by heat to produce a solid substance similar to glass. In this manner, porcelain may be enameled to metal or simply baked into a solid mass of pure porcelain. Restorations are usually fabricated on a replica or die of the prepared tooth. Materials may be added to the porcelain powders which improve color and strength.

[0003] Another method of fabricating dental restorations is hot-pressing (high temperature injection molding). This technique is initiated by creating the restoration in wax. The wax pattern is lifted from the die and invested or surrounded by a mix of "plaster-like" material which is allowed to harden. A channel or opening leads from the outer surface of the investment into the wax pattern. Wax is eliminated from the investment during a burnout procedure. The dental porcelain, provided in powder or pellet form, is placed in a special hot press and is melted and forced under pressure into the opening of the investment. Examples of porcelain pellets include soft-sintered OPC® pellets sold by Jeneric/Pentron Incorporated (Wallingford, Connecticut) and fully fused Empress® porcelain pellets sold by Ivoclar AG (Schaan, Liechtenstein). The melted material fills the void created by the wax pattern. After cooling, the hardened ceramic is broken out of the investment. Where desired, color can be baked onto the surface of the restoration to simulate tooth color.

[0004] Yet another method of fabricating dental restorations involves the computer-aided design, i.e., CAD/CAM, technique. In such a method, a 3-dimensional photo is taken of the stump of tooth over which a dental restoration is to be placed and of the teeth surrounding the stump. This photo is digitized and supplied to the CAD/CAM system, displaying the 3-dimensional picture on a viewing screen. The dental practitioner selects the most suitable tooth form from a plurality of tooth forms stored in the CAD/CAM system and projects the image of the selected tooth form over the stump until an optimum positioning and fit of the dental restoration is obtained. The digital data concerning the dental restoration thus formed are supplied to a numerically controlled milling machine operating in three dimensions, which

precisely cuts a blank, i.e., a solid piece of metal or fully fused dental porcelain, on the basis of the digital data to provide the dental restoration.

[0005] It has been observed that use of fully fused dental porcelain pellets wear down cutting tools and significantly slow down the process of dental restoration fabrication. The milling of fully fused dental porcelains results in excessive chipping and flaking, thus affecting the precision of the milling operation and, ultimately, the fit between the restoration and the patient's natural teeth.

[0006] It is an object of the present invention to provide a CAD/CAM method of making a dental restoration which significantly reduces the wear of cutting tools on milling machines controlled by CAD/CAM and improves the fit between the dental restoration and the patient's natural teeth.

### SUMMARY OF THE INVENTION

[0007] In accordance with these and other objects of the present invention, a method of making a dental restoration is provided which comprises:

providing a soft-sintered dental porcelain pellet;  
milling the soft-sintered pellet under the control of a CAD/CAM system to provide a tooth structure;  
investing the tooth structure with an investment refractory material to provide an invested tooth structure;  
fusing the invested tooth structure; and  
removing the investment refractory material from the fused tooth structure to provide the dental restoration.

[0008] The phrase "soft-sintered dental porcelain pellet" as utilized herein shall be understood to refer to a pellet that is formed by compressing at ambient temperature dental porcelain powder into a pellet (possessing any desired shape and configuration) and subsequently heating the pellet to a temperature which is sufficiently below the fusion temperature of the dental porcelain such that the density of the resulting soft-sintered pellet is less than about 85 percent, typically less than about 75 percent, of the theoretical density of the pellet. Such soft-sintered pellets possess a white, chalky appearance and are somewhat porous. This situation is to be contrasted with the case where the pellets are heated to a temperature which is at or close to the fusion temperature of the dental porcelain such that the density of the resulting sintered pellet is greater than about 90 percent of the theoretical density of the pellet. Such fully fused pellets possess a translucent, glossy appearance and exhibit very little, if any, porosity.

[0009] The term "tooth structure" as utilized herein includes milled soft-sintered pellets possessing shapes which replicate natural teeth or are intended to be in association with natural teeth.

[0010] One of the surprising advantages of the present invention is that dental restorations produced via the method of this invention exhibit significantly higher strength characteristics compared to dental restorations fabricated from fully fused pellets instead of soft-sintered pellets.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0011] CAD/CAM techniques and/or systems which can be utilized in the practice of this invention are not particularly limited and can include those described, for example, in U.S. Patent Nos. 4,575,805 and 4,663,720. An example of a commercially available CAD/CAM system which can advantageously be utilized in the practice of this invention is the PRO-CAM™ system available from IntraTech Dental Products (Dallas, Texas).

[0012] The dental porcelain used to fabricate the soft-sintered pellet utilized herein is likewise not particularly limited. Preferably, the dental porcelain is high strength Optec™ porcelain powder sold by Jeneric/Pentron Incorporated (Wallingford, Connecticut). Optec™ porcelain powder possesses a fusion temperature of about 1027°C. To fabricate Optec™ porcelain powder into a soft-sintered pellet, a suitable amount of powder is placed in a suitable pressing device, e.g., a Carver laboratory press, and compressed under pressure, e.g., 5000 psi, into a pellet at ambient temperature. Thereafter, the pellet is heated, e.g., in a conventional dental porcelain oven, to a temperature ranging from about 650 to about 925°C to soft-sinter the pellet. The resulting soft-sintered pellet possesses a density which is less than about 85, typically less than about 75, percent of the theoretical density of the pellet (as measured by Archimedes method).

[0013] Alternatively and more preferably, the soft-sintered pellet is a high strength OPC® porcelain pellet sold by Jeneric/Pentron Incorporated (Wallingford, Connecticut). OPC® porcelain pellets are sold in the soft-sintered form and thus can be readily used in the practice of this invention. OPC® porcelain pellets possess a fusion temperature of about 1150°C.

[0014] After the soft-sintered pellet has been milled under the control of a CAD/CAM system to provide a desired tooth structure, the resulting tooth structure is invested with an investment refractory material. The investment refractory material selected depends on the composition of the soft-sintered pellet. It is well known in the art that the investment refractory material should not change dimension when heated to high temperatures. Preferably, the refractory investment material possesses a coefficient of thermal expansion which is about  $0.5 \times 10^{-6}/^{\circ}\text{C}$  less than that of the soft-sintered dental porcelain pellet. When Optec™ porcelain is employed in the method herein, it is preferred in the practice of the method herein to employ Optec™ Instant Refractory Material sold by Jeneric/Pentron Incorporated

(Wallingford, Connecticut) as the investment refractory material. When OPC® soft-sintered porcelain pellets are employed, it is preferred to employ OPC® Instant Refractory Material sold by Jeneric/Pentron Incorporated (Wallingford, Connecticut) as the investment refractory material.

[0015] The invested tooth structure is then fused by heating the pellet in a vacuum furnace to the fusion temperature of the soft-sintered pellet as is well known in the art.

[0016] After the fused tooth structure has cooled, the investment material is removed from the fused tooth structure to provide a dental restoration which will precisely fit the tooth being restored and the surrounding teeth. Of course, it will be understood that veneering porcelain and/or stains may be subsequently placed on top of the outer surface of the resulting dental restoration utilizing techniques which are well known in the art.

[0017] The following example illustrates the practice of the present invention.

#### EXAMPLE

[0018] An OPC® soft-sintered dental porcelain pellet (available from Jeneric/Pentron, Inc., Wallingford, Connecticut) is machined into a tooth structure in partial shape or final shape using a PRO-CAM™ (trademark of IntraTech Dental Products Inc.) computer-assisted milling machine (available from Jeneric/Pentron Incorporated, Wallingford, Connecticut). The tooth structure is then invested with an investment refractory material (sold by Jeneric/Pentron Incorporated under the trade-name Optec™ Instant Refractory material) which does not change dimension when exposed to high temperature. The invested tooth structure is fused by placing the sample in a conventional dental porcelain furnace at an initial temperature of 650° C and increasing the temperature to 1150° C at a heat-up rate of 55° C/min. The tooth structure is held at 1150° C for 30 seconds. The fully fused tooth structure is cleaned of the investment to provide a dental restoration which is prepared to receive a suitable veneering porcelain. The fully fused dental restoration has sufficient viscosity when re-heated to the maturing temperature of the veneering porcelain such that it does not lose its shape during the firing cycle of the veneering porcelain. At maturity, the veneering porcelain forms a tight impervious surface necessary in the oral environment. Optimal™ porcelain (Jeneric/Pentron, Inc., Wallingford, Connecticut) is provided as a powder and is mixed with water or other suitable liquid to form a slurry. The slurry is applied to the dental restoration in accordance with well-known techniques and fused in a conventional dental porcelain furnace by heating the coated dental restoration from about 650° C to about 970° C at a heat-up rate of about 55° C/min. and holding at about 970° C for 30 seconds. The resultant coated dental porcelain restoration fits back into the original model.

[0019] Further variations and modifications of the present invention will become apparent to those skilled in the art from the foregoing within the scope of the claims appended hereto.

## Claims

1. A method of making a dental restoration which comprises:
  - providing a soft-sintered dental porcelain pellet, said pellet being formed by compressing at ambient temperature dental porcelain powder and heating the same at a temperature which is sufficiently below the fusion temperature of the dental porcelain such that the density of the resulting soft-sintered pellet is less than 85 percent of the theoretical density of the pellet;
  - milling the soft-sintered dental porcelain pellet under the control of a CAD/CAM system to provide a tooth structure ;
  - investing the tooth structure with an investment refractory material to provide an invested tooth structure ;
  - fusing the invested tooth structure ; and
  - removing the investment refractory material from the fused tooth structure to provide the dental restoration.
2. The method of claim 1 wherein the dental porcelain powder used to fabricate the soft-sintered dental pellet possesses a fusion temperature of about 1027°C.
3. The method of claim 2 wherein the temperature ranges from about 650 to about 925°C.
4. The method of claim 1 wherein the soft-sintered pellet possesses a fusion temperature of about 1150°C.
5. The method of claim 1 wherein the soft-sintered dental porcelain pellet possesses a density which is less than about 75 percent of the theoretical density of the pellet.
6. The method of claim 1 wherein the soft-sintered pellet is formed by compressing at ambient temperature dental porcelain powder into a pellet and subsequently heating the pellet to a temperature below the fusion temperature of the dental porcelain to provide a pellet possessing a density which is less than about 75 percent of the theoretical density.

7. The method of claim 5 wherein the dental porcelain powder used to fabricate the soft-sintered dental pellet possesses a fusion temperature of about 1027°C.

8. The method of claim 7 wherein the temperature ranges from about 650 to about 925°C.

## 10 Patentansprüche

1. Ein Verfahren zur Zahnbehandlung, bestehend aus:
  - Bereitstellung eines weich gesinterten dentalen Porzellan-Pellets, wobei besagtes Pellet durch Kompression eines dentalen Porzellanpulvers bei Raumtemperatur und Erhitzen desselben bei einer Temperatur gebildet wird, die ausreichend unter der Schmelztemperatur des dentalen Porzellans derart ist, daß die Dichte des daraus resultierenden weich gesinterten Pellets niedriger ist als 85 Prozent der theoretischen Dichte des Pellets;
  - Vermahlen des weich gesinterten dentalen Porzellan-Pellets unter der Kontrolle eines CAD/CAM-Systems zur Lieferung einer Zahnstruktur;
  - Investieren der Zahnstruktur mit einem investierungsbeständigen Material zur Bereitstellung einer investierten Zahnstruktur;
  - Verschmelzen der investierten Zahnstruktur; und
  - Entfernen des investierungsbeständigen Materials aus der geschmolzenen Zahnstruktur zur Bereitstellung der Zahnbehandlung.
2. Verfahren gemäß Anspruch 1, in dem das zur Herstellung des weich gesinterten dentalen Pellets verwendete dentale Porzellanpulver eine Schmelztemperatur von ungefähr 1 027°C besitzt.
3. Verfahren gemäß Anspruch 2, in dem die Temperatur zwischen ungefähr 650 bis ungefähr 925°C beträgt.
4. Verfahren gemäß Anspruch 1, in dem das weich gesinterte Pellet eine Schmelztemperatur von ungefähr 1 150°C beträgt.
5. Verfahren gemäß Anspruch 1, in dem das weich gesinterte dentale Porzellan-Pellet eine Dichte besitzt, die niedriger als ungefähr 75 Prozent der theoretischen Dichte des Pellets beträgt.
6. Verfahren gemäß Anspruch 1, in dem das weich gesinterte Pellet durch Kompression eines dentalen Porzellanpulvers in ein Pellet bei Raumtemperatur,

und anschließendes Erhitzen des Pellets auf eine Temperatur unterhalb der Schmelztemperatur des dentalen Porzellans zur Bereitstellung eines Pellets gebildet wird, das eine Dichte besitzt, die niedriger als ungefähr 75 Prozent der theoretischen Dichte liegt.

7. Verfahren gemäß Anspruch 5, in dem das zur Herstellung des weich gesinterten dentalen Pellets verwendete dentale Porzellanpulver eine Schmelztemperatur von ungefähr 1 027°C besitzt. 10
8. Verfahren gemäß Anspruch 7, in dem die Temperatur zwischen ungefähr 650 bis ungefähr 925°C beträgt. 15

#### Revendications

1. Procédé pour préparer une prothèse dentaire qui comprend : 20
  - la disposition d'une pastille de porcelaine dentaire frittée tendre, ladite pastille étant formée par compression, à température ambiante, de poudre de porcelaine dentaire et chauffage de celle-ci à une température qui est suffisamment inférieure à la température de fusion de la porcelaine dentaire pour que la densité de la pastille frittée tendre résultante soit inférieure à 85 % de la densité théorique de la pastille ; 25
  - le broyage de la pastille de porcelaine dentaire frittée tendre sous le contrôle d'un système CAD/CAM pour réaliser une structure de dent ; 30
  - le revêtement de la structure de dent avec un matériau réfractaire ce revêtement pour réaliser une structure de dent revêtue ; 35
  - la fusion de la structure de dent revêtue ; et
  - le retrait du matériau réfractaire de revêtement depuis la structure de dent fusionnée pour réaliser la prothèse dentaire. 40
2. Procédé selon la revendication 1, dans lequel la poudre de porcelaine dentaire utilisée pour fabriquer la pastille dentaire frittée tendre possède une température de fusion d'environ 1027°C. 45
3. Procédé selon la revendication 2, dans lequel la température est située dans la plage allant d'environ 650 à environ 925°C. 50
4. Procédé selon la revendication 1, dans lequel la pastille frittée tendre possède une température de fusion d'environ 1150°C. 55
5. Procédé selon la revendication 1, dans lequel la pastille de porcelaine dentaire frittée tendre possède une densité qui est inférieure à environ 75 % de

la densité théorique de la pastille.

6. Procédé selon la revendication 1, dans lequel la pastille frittée tendre est formée par compression, à température ambiante, de poudre de porcelaine dentaire en une pastille et ensuite chauffage de la pastille à une température inférieure à la température de fusion de la porcelaine dentaire pour réaliser une pastille possédant une densité qui est inférieure à environ 75 % de la densité théorique.
7. Procédé selon la revendication 5, dans lequel la poudre de porcelaine dentaire utilisée pour fabriquer la pastille dentaire frittée tendre possède une température de fusion d'environ 1027°C.
8. Procédé selon la revendication 7, dans lequel la température est située dans la plage allant d'environ 650 à environ 925°C.